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NATIONAL DAM INSPECTION REPORT. BOYERTOWN RESERVOIR DAM (NDI-PA--ETC(U)
AUG 79 J J WILLIAMS DACW31-79-C-0010

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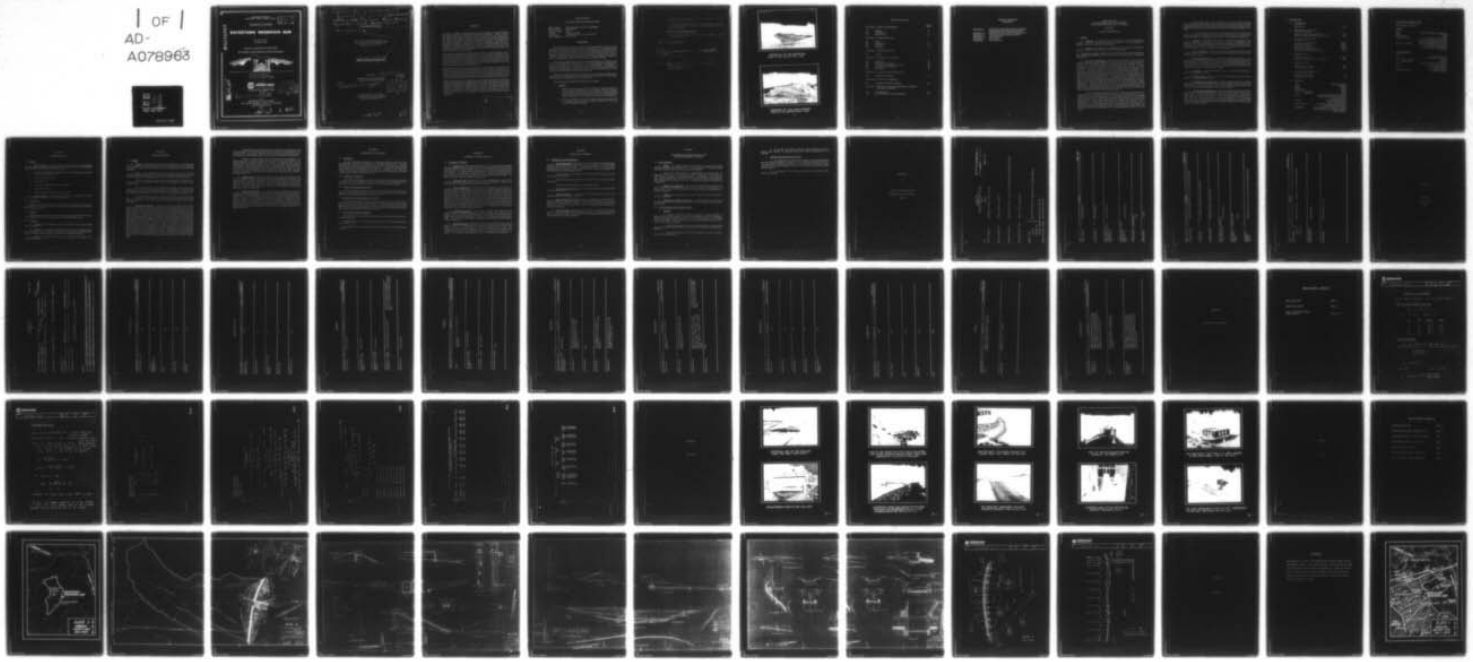

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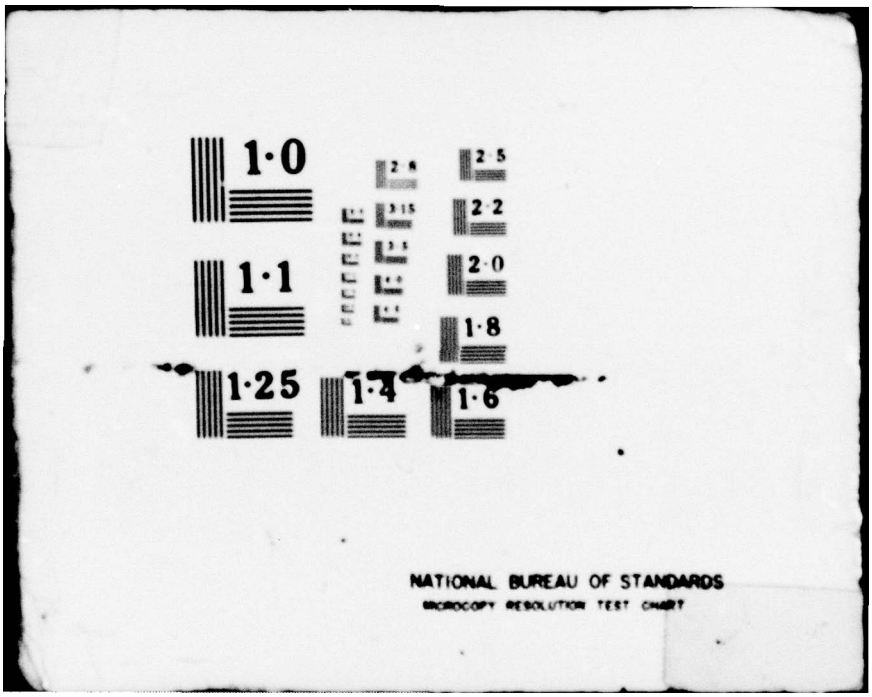
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DELAWARE RIVER BASIN
POPODICKON CREEK, BERKS COUNTY

LEVEL II

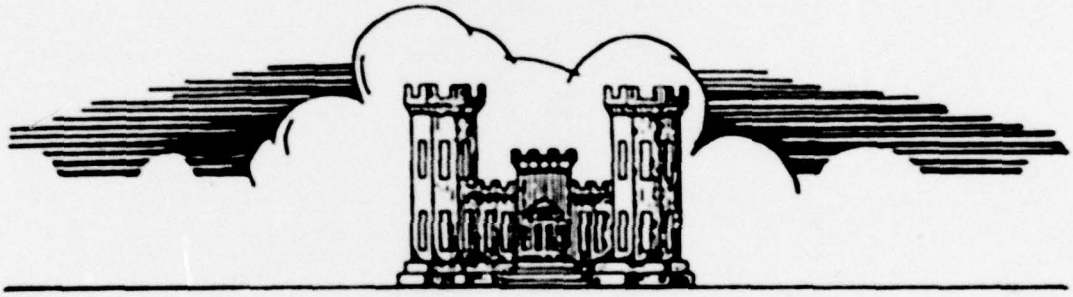
PENNSYLVANIA

BOYERTOWN RESERVOIR DAM

NDI-PA 00707
PA DER 6-344

AD A078963

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



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O'BRIEN & GERE
Justin & Courtney Division
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19103

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FOR

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT CORPS OF ENGINEERS
BALTIMORE, MARYLAND
21203

AUGUST 1979

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(6) National Dam Inspection Report. Boyertown Reservoir Dam (NDI-PA 00707) (PA DER 6-344) Delaware River Basin, Popodickon Creek, Berks County, Pennsylvania.

DELAWARE RIVER BASIN

Name of Dam: Boyertown Reservoir Dam
County & State: Berks County, Pennsylvania
Inventory Number: PA00707

(10) John J. Williams

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared by: (11) Aug 79 (12) 71

O'BRIEN & GERE ENGINEERS, INC
JUSTIN & COURTNEY DIVISION

(13) DACW31-79-C-0010

For

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

410760

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I REPORT

NATIONAL DAM INSPECTION PROGRAM

Name of Dam:	Boyertown Reservoir Dam ID #PA00707
State Located:	Pennsylvania
County Located:	Berks
Stream:	Popodickon Creek
Coordinates:	Latitude 40° 20.4', Longitude 75° 41.0'
Date of Inspection:	May 15, 1979

ASSESSMENT

Boyertown Reservoir Dam is an earth and rockfill embankment with a concrete corewall and a 20-foot wide, broad-crested, concrete spillway. The upstream portion of the dam is rolled earth embankment; the downstream section is earth and rockfill. The dam is approximately 620 feet long with a maximum height of 55 feet and impounds a reservoir with a normal pool storage capacity of 105 acre-feet. The dam is located on Popodickon Creek and serves as a source of water supply for Boyertown, which is situated approximately 2.5 miles downstream (east) of the dam.

The Spillway Design Flood (SDF) for this "Intermediate" size, "High" hazard dam is the Probable Maximum Flood (PMF). The spillway is capable of discharging 37 percent of the PMF without overtopping of the embankment. The spillway is classified as "Inadequate". The spillway is not classified as "Seriously Inadequate" because the depth and duration of overtopping are not considered sufficient to cause a failure of the embankment at 50 percent of the PMF.

Based on the visual observations and review of the information obtained from the Pennsylvania Department of Environmental Resources, Division of Dam Safety, Boyertown Dam is considered to be in good condition.

Recommendations and Remedial Measures are as follows:

a. Facilities.

1. The top of the dam should be restored to design elevation as determined by a detailed survey. As a result, the hydraulic capacity of the spillway would be increased by about 60 cfs so that about 45 percent of the PMF could be discharged. Surface monuments should be placed along the top of the dam to monitor any future settlement.

2. Detailed hydrologic and hydraulic analyses should be performed and the spillway capacity should be further increased to make the spillway hydraulically adequate.

3. A bare spot on the downstream slope should be reseeded to prevent erosion from surface runoff.

4. The cracks in the spillway discharge channel should be repaired to prevent scour beneath the discharge channel and further deterioration of the concrete.

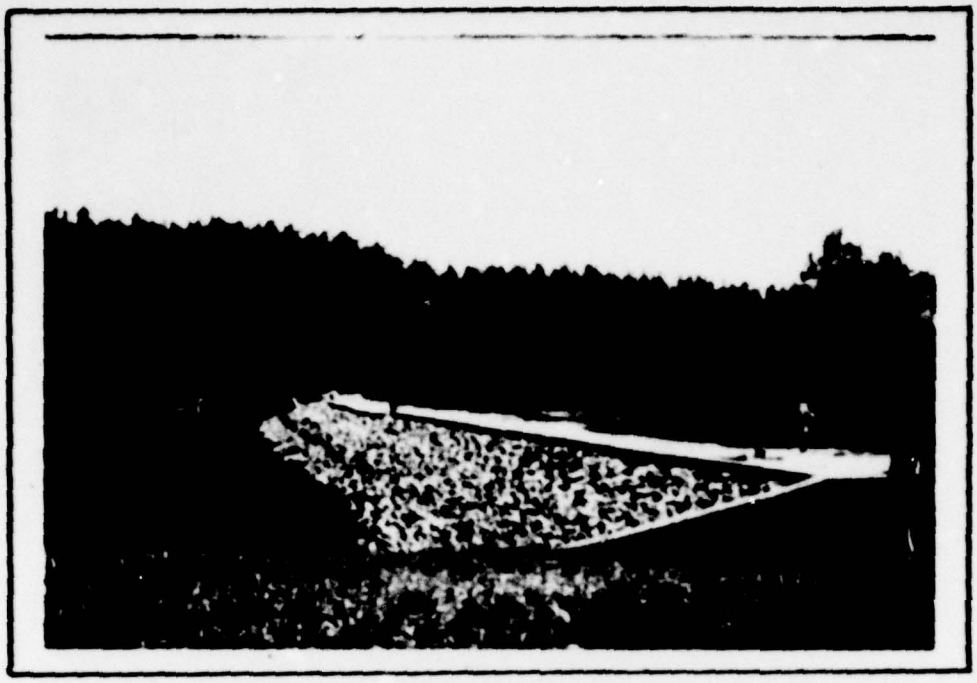
b. Operation and Maintenance Procedures.

1. The adequacy of the warning systems that are currently in effect should be evaluated.

O'BRIEN & GERE ENGINEERS, INC.
JUSTIN & COURTNEY DIVISION

John J. Williams Date: 5 Sept. 1979
John J. Williams, P.E.
Vice President
Pennsylvania Registration PE006920E

Approved by: James W. Peck Date: 19 Sep 79
JAMES W. PECK
Colonel, Corps of Engineers
District Engineer



OVERVIEW OF THE UPSTREAM
FACE OF THE BOYERTOWN DAM

OVERVIEW OF THE DOWNSTREAM
FACE OF THE BOYERTOWN DAM

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(Continued)

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM
BOYERTOWN RESERVOIR DAM ID #PA00707

SECTION 1

PROJECT INFORMATION

1.1 General

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of this inspection is to determine if Boyertown Reservoir Dam constitutes a hazard to human life or property.

1.2 Description of Project (Based upon information obtained from the Pennsylvania Department of Environmental Resources (DER), Division of Dam Safety, Harrisburg, Pennsylvania)

a. Dam and Appurtenances. Boyertown Reservoir Dam is an earth and rockfill embankment, approximately 620 feet long with a maximum height of about 55 feet and a crest width of 14 feet at Elevation 630.0. The upstream slope is 3 horizontal to 1 vertical (3H:1V) and the downstream slope is 2H:1V. The dam impounds a reservoir with a surface area of 9 acres and normal pool storage of 105 acre-feet. The dam consists of a central concrete corewall supported by a downstream earth and rock fill and an upstream rolled earth embankment. The corewall is step-tapered in section and has a base width of 5 feet which reduces to 2 feet at the top. The corewall extends from Elev. 628.0 to an average depth of about 4 feet below the original ground line. The upstream slope is protected by stone paving from the top of the dam to Elev. 611.0 where it terminates with a stone toe wall. A 6-foot square vertical shaft backfilled with stone and puddled clay is situated beneath the concrete corewall about 330 feet from the left abutment (looking downstream). The shaft, which was installed to collect discharge from a pervious substratum, is connected at Elev. 561.6 to a 6-foot square timbered gallery. The gallery extends about 200 feet downstream at a 0.5% slope where it directs discharge into a catch basin connected to the water supply system.

A broad-crested, concrete spillway with an Ogee nappe is located at the right abutment. The spillway is 20 feet wide and has a 3-foot drop from the weir crest (Elev. 625.0) to the discharge apron. A concrete training wall and a riprapped abutment slope form a 17-foot long approach channel which has a 1-foot thick concrete invert. The concrete outlet channel (invert Elev. 622.0) extends 15.5 feet downstream, is 20 feet wide, and includes an 18-inch long transition from a rectangular to a trapezoidal channel section. This stone paved section reduces to a 10-foot wide invert and continues for about 220 feet downstream at a 12% slope. The remaining 130 feet of the outlet channel is a trapezoidal earth section on a 15.4% slope.

The reservoir drain system consists of a concrete intake structure provided with three inlets at Elev. 591.0, 603.0 and 614.0. The inlets are controlled by sluice gates operated from the gatehouse, which is located approximately 50 feet upstream of the top of the dam and about 230 feet from the left abutment of the dam.

Two 12-inch cast iron concrete encased outlet pipes, one for water supply and one for reservoir drawdown, are located in the intake structure at invert Elev. 589.0. Both pipes are controlled by hand-operated 12-inch valves in the gatehouse.

b. Location. Boyertown Reservoir Dam is located on Popodickon Creek about 2.5 miles west of Boyertown, Pennsylvania. The dam is situated within Earl Township in Berks County and is shown on the USGS Quadrangle entitled, "Boyertown, Pennsylvania" at coordinates N 40° 20.4', W 75° 41.0'. A regional location plan of Boyertown Reservoir Dam is enclosed as Plate 1, Appendix E.

c. Size Classification. The maximum height of 55 feet and maximum pool storage capacity of 156 acre-feet place Boyertown Reservoir Dam in the "Intermediate" size category.

d. Hazard Classification. An existing water treatment plant and a new treatment plant, which is under construction are located near the downstream toe of the embankment. In addition, several homes are located along Popodickon Creek less than one-half mile downstream of the dam. Failure of Boyertown Reservoir Dam would cause extensive property damage and probable loss of life in these areas. Therefore, the dam is classified as "High" hazard.

e. Ownership. Boyertown Reservoir Dam is owned by the Borough of Boyertown, Pennslyvania 19512.

f. Purpose of Dam. The dam was constructed to impound a water supply reservoir for the Borough of Boyertown.

g. Design and Construction History. Boyertown Reservoir Dam was designed and constructed by William H. Dechant and Sons, Engineers-Architects, Reading, Pennsylvania. Construction began in April of 1926 and was completed in May 1929. There is no record of any subsequent modifications to the dam.

h. Normal Operating Procedures. Hand operated gate hoists are provided for the control of the three inlet sluice gates and the two outlet gates located in the intake tower. Two inlet pipes and one outlet pipe are provided for water supply. These pipes are controlled by sluice gates which are operated from the gatehouse. A third inlet pipe and second outlet pipe allow for drawdown of the reservoir. According to Mr. Roland Reed, Boyertown Borough Manager, the drawdown sluice gates are operated periodically, but only during high reservoir stages to insure that a minimum of water is wasted.

1.3 Pertinent Data

a. Drainage Area.

Square Miles	0.5

b. Discharge at Dam Site. (cfs)

Maximum Flood of Record (estimated)	175
Spillway discharge, reservoir at crest of dam	700

c. Elevation. (feet above MSL)

Spillway Crest (normal pool)	625.0
Top of Dam (Design)	630.0
Top of Dam (Low Point)	629.5
Reservoir Drain Invert (inlet)	590.0
Streambed at downstream toe of dam	575±

d. Reservoir. (miles)

Length of Normal Pool	0.19
Length of Maximum Non-overtopping Pool	0.20

e. Storage. (acre-feet)

Normal Pool, Elev. 625.0	105
Top of Dam, Elev. 630.0	156

f. Reservoir Surface Area. (acres)

Normal Pool, Elev. 625.0	9
Top of Dam, Elev. 630.0	13

g. Dam Data.

Type	Earth and Rock Fill
Length	620 feet
Height	55 feet
Crest Width	14 feet
Side Slopes (upstream)	3H:1V
(downstream)	2H:1V
Zoning	Concrete corewall with a rolled earth upstream shell and earth and rockfill downstream shell.
Cutoff	Concrete corewall extends 4 feet into overburden.
Grout Curtain	Grout tubes installed at 8-foot centers in concrete core wall; not used.
Underdrain	A 6-foot square well backfilled with stone and connected to a 6-foot square timbered drainage gallery.

h. Diversion and Regulating Tunnel.

Does not apply to this site.

i. Spillway.

Type	Broad-crested weir with Ogee cap.
Width	20 feet
Crest Elevation	625.0
Upstream Channel	17-foot long concrete apron at Elevation 624.7 with concrete training wall and riprapped abutment slope.
Downstream Channel	Rectangular concrete section (invert Elev. 622.0) with transition to stone paved trapezoidal channel at 12% slope.

j. Regulating Outlets.

Type	Two 12-inch cast iron pipes encased in concrete.
Length (Reservoir Drain)	165 feet
(water supply)	Unknown
Closure	12-inch gate valves on both conduits at intake structure.
Access	Upstream gate house over intake structure.
Regulating Facilities	Hand operated wheels.

SECTION 2

ENGINEERING DATA

2.1 Design

a. Data Available. The information available for review of Boyertown Reservoir Dam includes the following (all information contained in the Pennsylvania DER main office files in Harrisburg, Pennsylvania):

1. "Permit", "Application", and "Report upon the Application"to construct Boyertown Reservoir Dam, 1926.

2. Construction specifications.

3. Design drawings.

4. Construction progress reports and photographs.

5. Inspection reports.

6. Miscellaneous correspondence and memoranda.

b. Design Features. The principal design features are described in Section 1.2.a. (Description of Project, Dam and Appurtenances).

2.2 Construction

Based on the field investigation and the information available in the construction reports, the dam appears to have been constructed in general conformance with the final design drawings.

2.3 Operation

Operation procedures are limited to the sluice gates located in the intake tower which control the inflow to the water supply and reservoir drawdown pipes.

2.4 Evaluation

a. Availability. The engineering information utilized in this report was made available by DER.

b. Adequacy. The available data (listed in Section 2.1.a), visual observations and conversations with the Owner's representative, Mr. Roland Reed, Boyertown borough Manager, provided adequate information for a Phase I investigation.

c. Validity. There appears to be no reason to question the validity of the data provided by DER.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. General. The field inspection of Boyertown Reservoir Dam took place on May 15, 1979. At the time of the inspection, the water surface was approximately one foot below the spillway crest elevation. No underwater areas of the dam were inspected.

b. Dam. A survey revealed that the top of dam has settled several inches below design elevation along most of its length. A maximum depression of about six inches was observed from approximately 80 to 140 feet to the left of the spillway.

The riprap cover on the upstream face of the embankment appears to be in good condition. The riprap is fairly well graded, consisting of 6-inch to 2-foot rounded stone.

The downstream slope of the embankment supports a good cover consisting mainly of crown vetch. A bare spot about 50 feet by 100 feet was observed near the downstream toe approximately 200 feet from the left abutment. This bare spot was apparently related to the construction work on the new water treatment plant.

Gravel bordered by concrete curbing on either side covers the top of the dam. The curbing is about 5 inches thick and extends approximately 6 inches above the top of the dam. The curbing is out of alignment near the center of the embankment.

c. Appurtenant Structures. The spillway section and approach apron appear to be in good condition. A 12-inch diameter cast iron pipe is suspended from the left spillway training wall by metal brackets with the pipe invert about 6 inches above the spillway crest. According to Mr. Roland Reed, Boyertown Borough Manager, the pipe was installed around 1949 to provide additional water supply to the reservoir from Ironstone Creek. The spillway discharge channel is a composite section which differs from the channel section shown in the design drawings. Instead of a riprap lined channel which changes to a trapezoidal earth cut, the channel is brick-lined with a 5-foot wide concrete chute in the center for the entire 350-foot length. The channel side slopes are riprap lined. Numerous cracks in the concrete portion of the discharge channel were observed during the inspection. A trickle of water (0.1 gpm) was flowing from a 12-inch diameter cast iron pipe which serves as the backwash line for the treatment plant and directs flow into the spillway discharge channel about 200 feet downstream of the spillway. During the inspection, this water was seeping into the concrete cracks and emerging downsteam from beneath the channel section. The discharge channel passes beneath the access road to the old treatment plant by means of two 24-inch diameter concrete pipes and two 18-inch diameter concrete pipes.

The gatehouse and sluice gate controls appear to be well maintained and in good condition. A concrete foot bridge provides access to the gatehouse from the top of the dam. The reservoir drawdown outlet pipe terminates at the same point as the spillway discharge channel, at the natural streambed about 300 feet downstream.

There is no evidence that the timber gallery is still in existence. In a letter dated 1926, Mr. William Dechant (the designer) stated that the timber in the gallery would be structurally sound for 15 or 20 years. He suggested that if the use of the gallery is still required after this period of time, the timber should be replaced with masonry. There is no record of any such modification and Mr. Reed stated that, to the best of his knowledge, the timber has never been removed. Neither Mr. Reed nor Mr. Lynn Griffith, Assistant Chief Engineer for Glace and Glace Engineers (Engineers responsible for the new water treatment plant design) knew if the gallery was still functioning.

d. Reservoir Area. The reservoir slopes are fairly steep and heavily wooded. A 12-inch diameter cast iron pipe extends from the right reservoir slope about 100 feet upstream of the dam. The invert of the pipe was about one foot above the reservoir surface during the inspection. According to Mr. Reed, this pipe allows water to be pumped from Trout Run Reservoir (2 miles away) into Boyertown Reservoir. Water may also be pumped directly into the Boyertown water supply system from Trout Run Reservoir.

e. Downstream Channel. The spillway discharge channel and reservoir drawdown outlet pipe both terminate at a small stilling basin approximately 300 feet downstream of the embankment. Beyond this basin, the natural stream (Popodickon Creek) resumes its course and flows beneath an access bridge for the new treatment plant by means of a 42-inch diameter corrugated metal pipe. Popodickon Creek continues downstream for about 1.5 miles on an approximate grade of 3 percent where it merges with Ironstone Creek in the town of Gabelsville. Approximately 10 people at the water treatment plant and about 20 people in 5 homes located along the stream between the dam and Gabelsville would be subject to danger in the event of a failure of the dam.

SECTION 4

OPERATIONAL PROCEDURES

4.1 Procedures

The only operational procedures for Boyertown Reservoir Dam are those concerning the control of the water supply to the Borough of Boyertown. Two inlet pipes and one outlet pipe are provided for water supply. These pipes are controlled by sluice gates which are operated from the gatehouse. A third inlet pipe and second outlet pipe allow for drawdown of the reservoir. According to Mr. Reed, the drawdown sluice gates are operated periodically, but only during high reservoir stages to insure that a minimum of water is wasted.

4.2 Maintenance of the Dam

According to the Owner's representative, maintenance is performed as needed by a labor crew from the Boyertown Streets Department. The dam and appurtenant structures are inspected regularly by workers from the water treatment plant.

4.3 Maintenance of Operating Facilities

The only operating facilities are the sluice gates which control the inflow and outflow for water supply and reservoir drawdown. The gate hoists and control wheels appear to be well maintained and are in good condition.

4.4 Description of any Warning Systems in Effect

According to Mr. Reed, Boyertown Reservoir Dam is tied in with the Berks County Civil Defense System. The Borough of Boyertown also has a Wells Fargo warning system in effect. The Borough's Emergency Center is located in the Borough Hall. In this system, water levels are monitored and during dangerously high stages an alarm would be sounded at the Emergency Center.

4.5 Evaluation of Operational Adequacy

The maintenance and operational procedures for Boyertown Reservoir Dam are considered adequate.

It appears that the dam is accessible under all weather conditions for inspection and emergency action.

The adequacy of the warning systems that are currently in effect should be evaluated.

SECTION 5

HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features

a. Design Data. Boyertown Reservoir Dam has a drainage area of 0.5 square miles and impounds a reservoir with a normal pool storage capacity of 105 acre-feet. Ground elevations range from 1080 in the upper reaches of the drainage basin to 625 at normal pool. The slopes of the watershed adjacent to the reservoir range from 5 to 25 percent. The watershed is nearly 100 percent wooded. The spillway is a 20-foot wide broad-crested concrete weir with an Ogee-shaped downstream nappe. The spillway discharge capacity is approximately 700 cfs.

b. Experience Data. According to the Owner's representative, high and low flows are monitored at the treatment plant immediately downstream. There are no known rainfall or reservoir level records kept for this dam.

c. Visual Observations. On the day of the inspection, there were no indications that the spillway could be obstructed. The spillway discharge channel is a composite section which differs from the channel section shown in the design drawings. Instead of a riprap lined channel which changes to a trapezoidal earth cut, the channel invert is brick-lined with a 5-foot wide concrete chute in the center for the entire 350-foot length. The channel side slopes are riprap lined. Numerous cracks in the concrete portion of the discharge channel were observed during the inspection. A trickle of water (0.1 gpm) was flowing from a 12-inch diameter cast iron pipe which serves as the backwash line for the treatment plant and directs flow into the spillway discharge channel about 200 feet downstream of the spillway. During the inspection, this water was seeping into the concrete cracks and emerging downstream from beneath the channel section.

d. Overtopping Potential. The Spillway Design Flood (SDF) for this "Intermediate" size, "High" hazard structure is the full PMF. The peak inflow and outflow rates for the PMF were determined to be 1985 cfs and 1934 cfs, respectively. Based on the hydrologic analyses, the spillway is capable of discharging approximately 37 percent of the PMF without overtopping of the embankment (see Appendix C for computations).

e. Spillway Adequacy. Although the spillway is not capable of discharging 50 percent of the PMF, the dam would only be overtopped by a maximum of 0.34 feet (about 4 inches) for a duration of 1.5 hours at 50 percent of the PMF. This overtopping is not considered sufficient to cause a failure of the embankment and, therefore, the spillway is not classified as "Seriously Inadequate". However, the spillway is not capable of discharging the SDF, so it is classified as "Inadequate".

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations. The top of dam survey revealed that settlement has occurred in the embankment so that the top of dam is several inches below design elevation along most of its length. The settlement could be a result of poor compaction during construction. The lowered top of dam reduces the capability of the embankment to withstand major floods.

The bare spot on the downstream slope exposes the embankment to rapid erosion from surface runoff.

The embankment slopes appear to be in good condition and show no signs of instability.

The spillway section appears to be structurally stable.

b. Design and Construction Data. The design and construction data available is listed in Section 2.1.a.

c. Operating Records. According to Mr. Roland Reed, records for the operation of the sluice gates are maintained.

d. Post-Construction Changes. Construction photographs indicate that the spillway discharge channel was originally riprap lined as designed. Sometime subsequent to the completion of construction the channel was repaved with brick and concrete as described in Section 3.1.c. There is no evidence of any other post construction changes.

e. Seismic Stability. Boyertown Reservoir Dam is located in Seismic Risk Zone 1 of the Seismic Zone Map of Contiguous States. A dam located in Seismic Zone 1 is generally considered to be safe under any expected earthquake loading, if it is stable under static loading conditions.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety. The visual observations and review of available information indicate that Boyertown Reservoir Dam is in good condition. However, several deficiencies noted in Section 6.1.a require further attention.

The SDF for this structure was determined to be the full PMF, as discussed in Section 5.1.c. The spillway is capable of discharging 37 percent of the PMF without overtopping of the embankment. The spillway is not considered "Seriously Inadequate" due to the short duration and limited depth of overtopping of the embankment at 50 percent of the PMF. Therefore, the spillway is classified as "Inadequate".

b. Adequacy of Information. No design calculations were obtained from DER. However, the available data (listed in Section 2.1.a), visual observations, and conversations with the Owner's representative, provided adequate information for a Phase I investigation.

c. Urgency. The remedial measures recommended in Section 7.2 should be effected immediately.

d. Necessity for Further Investigation. Detailed hydrologic and hydraulic studies should be made to determine the extent to which the spillway capacity should be increased.

7.2 Recommendations and Remedial Measures

a. Facilities

1. The top of the dam should be restored to design elevation as determined by a detailed survey. As a result, the hydraulic capacity of the spillway would be increased by approximately 60 cfs so that about 45 percent of the PMF could be discharged. Surface monuments should be placed along the top of the dam to monitor any future settlement.

2. Detailed hydrologic and hydraulic analyses should be performed and the spillway capacity should be further increased so that the spillway is hydraulically adequate.

3. The bare spot on the downstream face should be reseeded to prevent erosion from surface runoff.

4. The cracks in the spillway discharge channel should be repaired to prevent scour beneath the discharge channel and further deterioration of the concrete.

b. Operation and Maintenance Procedures.

1. The operation and maintenance procedures for Boyertown Reservoir Dam are considered adequate. In addition to those procedures described in Section 4, Mr. Reed stated that Boyertown Borough is in the process of developing a formal inspection and maintenance program with the Glace and Glace Engineering Company from Harrisburg.

2. The adequacy of the warning systems that are currently in effect should be evaluated.

APPENDIX

A

Check List Engineering Data

Design, Construction, Operation

Phase I

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Boyertown Dam

ID # PA 00707

ITEM	REMARKS
AS-BUILT DRAWINGS	No As-Built drawings were available.
REGIONAL VICINITY MAP	Refer to Plate 1, Appendix E
CONSTRUCTION HISTORY	Construction progress reports and photographs were obtained from DER.
TYPICAL SECTIONS OF DAM	Refer to Plate 2, Appendix E
OUTLETS - PLAN	Refer to the Plates in Appendix E for availabe drawings.
DETAILS	
CONSTRAINTS	
DISCHARGE RATINGS	None obtained from DER.
RAINFALL/RESERVOIR RECORDS	None obtained from DER.

ITEM	REMARKS
DESIGN REPORTS	None available.
GEOLOGY REPORTS	None available.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None available.
POST-CONSTRUCTION SURVEYS OF DAM	None
BORROW SOURCES	Unknown

ITEM	REMARKS
MONITORING SYSTEMS	Monitoring systems exist but no records were obtained.
MODIFICATIONS	No records of modifications were obtained.
HIGH POOL RECORDS	Recorded at water treatment plant.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None available
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None
MAINTENANCE OPERATION RECORDS	Operating records are kept at the water treatment plant.

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	Refer to the Plates in Appendix E for available drawings.
OPERATING EQUIPMENT PLANS & DETAILS	None available
MISCELLANEOUS	Refer to Section 2.1.a.

APPENDIX

B

Check List

Visual Inspection

Phase I

CHECK LIST
VISUAL INSPECTION
PHASE I

Name Dam Boyertown Dam County Berks State Pennsylvania National ID # PA 00707

Type of Dam Earth and Rockfill Hazard Category High

Date(s) Inspection May 15, 1979 Weather Clear Temperature 70o F

Pool Elevation at Time of Inspection 624 ± M.S.L. Tailwater at Time of Inspection 576± M.S.L.

Inspection Personnel:

J. J. Williams Leonard R. Beck Robert R. Bowers

J. J. Williams Recorder

Remarks:

Mr. Roland Reed, Boyertown Borough Manager, Mr. Lynn Griffith, Assistant Chief Engineer from Glace & Glace Engineers, and Mr. Max Stoner, resident Inspector for the water treatment plant from Glace and Glace Engineers were also present during the inspection.

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	N/A	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	N/A	
DRAINS	N/A	
WATER PASSAGES	N/A	
FOUNDATION	N/A	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	N/A	
STRUCTURAL CRACKING	N/A	
VERTICAL AND HORIZONTAL ALIGNMENT	N/A	
MONOLITH JOINTS	N/A	
CONSTRUCTION JOINTS	N/A	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None observed	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	The entire length of the crest has settled below design elevation.	The crest should be restored to design elevation and surface monuments should be installed to monitor settlement.
RIPRAP FAILURES	None observed	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
DRAINS	The reservoir drain runs beneath the embankment.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No problems noted.	
ANY NOTICEABLE SEEPAGE	None observed.	
STAFF GAGE AND RECORDER	None	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	None observed.	
INTAKE STRUCTURE	The intake structure was submerged. The gate house above the intake structure appeared to be in good condition.	
OUTLET STRUCTURE	None	
OUTLET CHANNEL	The drawdown pipe terminates at a stilling basin in the natural stream channel.	
EMERGENCY GATE	The sluice gates which control the drawdown and water supply pipes are located in the gate house.	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	The weir appeared to be in good condition.	
APPROACH CHANNEL	A 17-foot long approach apron slopes gently up to a point just below the spillway crest.	
DISCHARGE CHANNEL	The discharge channel base is lined with brick and concrete which differs from the riprap lined section in the design drawings. The concrete portion of the channel was cracked in numerous places.	The cracks in the channel should be repaired so that no further deterioration or erosion takes place.
BRIDGE AND PIERS	None	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	N/A	
APPROACH CHANNEL	N/A	
DISCHARGE CHANNEL	N/A	
BRIDGE AND PIERS	N/A	
GATES AND OPERATION EQUIPMENT	N/A	

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER	None	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Reservoir slopes are steep and heavily wooded but show no signs of instability.	
SEDIMENTATION	Sedimentation level is unknown.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Immediately downstream of the stilling basin (at which point the natural stream channel resumes) the channel passes beneath an access road by means of a 42-inch diameter CMP. This pipe is the only apparent constriction to flow.	
SLOPES	The channel progresses downstream on a fairly steep gradient - approximately 3 percent.	
APPROXIMATE NO. OF HOMES AND POPULATION	Approximately 10 persons would be subject to danger in the water treatment plants immediately downstream. About 5 homes and approximately 20 additional persons would be endangered along the stream within a mile of the dam in the event of a failure.	

APPENDIX

C

Hydrologic & Hydraulic Data

TABLE OF CONTENTS - APPENDIX C

O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO
BOYERTOWN DAM	1	RRB	3/22/79	

HYDROLOGY CALCULATIONS

DRAINAGE AREA (PLANIMETERED ON USGS QUAD SHEET): 0.50 $mi.^2$

PMP CALCULATIONS (HMS REPORT 33)

AREA IS IN ZONE 6

24 HR., 200 SQ. MI. RAINFALL = 23"

HR.	T_o	RAINFALL	Δ RF
6	113	26.0"	26.0"
12	123	28.3"	2.3"
24	132	30.4"	2.1"
48	142	32.7"	2.3"

SNYDER COEFFICIENTS

FROM INFO. PROVIDED BY COE FOR THE DELAWARE RIVER BASIN, ZONE 7 (SCHUYLKILL RIVER SUB-BASIN):

$$C_p = 0.65$$

AND $C_t = 1.35$

$$t_p = C_t (L \cdot L_{ca})^{0.3}$$

$L = 0.9$ miles $\qquad L_{ca} = 0.3$ miles

$$t_p = 1.35 (0.9 \cdot 0.3)^{0.3} = \boxed{0.9 \text{ HRS.}}$$

O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO
BOYERTOWN DAM	1A			

STAGE-AREA INFORMATION

NORMAL POOL (EL. 625) SURFACE AREA = 9 ACRES (FROM INFO. PROVIDED BY PDER).

SURFACE AREA AT ELEVATION 640 = 22 ACRES (PLANIMETERED FROM USGS QUAD SHEET)

SURFACE AREA AT APPROXIMATE TOE OF DAM (EL. 595) IS DETERMINED FROM THE CONIC VOLUME EQUATION, USING THE KNOWN NORMAL POOL STORAGE OF 105 ACRE-FEET AND AN ASSUMED STORAGE OF 0 ACRE-FEET AT THE TOE ELEVATION.

$$\Delta V = \frac{\Delta h}{3}\left(\sqrt{A_1 A_2} + A_1 + A_2\right)$$

$$105\ A\cdot Ft = \frac{30\ Ft}{3}\left(\sqrt{9 A_2} + 9 + A_2\right)$$

TRY $A_2 = 0.2$ ACRES,

$$105 = 10\left(\sqrt{9(.2)} + 9 + .2\right)$$

$$105 = 105.4$$

THEREFORE, THE SURFACE AREA AT ELEV. 595 = 0.2 ACRES

THE TOP OF DAM ELEVATION CHOSEN FOR USE IN THIS PROGRAM IS 629.7 WHICH IS AN AVERAGE VALUE SO THAT AN AVERAGE DISCHARGE OVER THE TOP OF THE DAM WILL BE UTILIZED.

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  25 SEP 79
**********
    1                A1                    NATIONAL DAM INSPECTION PROGRAM
    2                A2                          HOYERTOWN DAM
    3                A3                          PMF HYDROGRAPH
    4                *    150       .0      30       0       0       0       0       0      -4       0
    5                N1    5
    6                J     1        9       1
    7                J1   .2       .3      .4      .5      .6      .7      .8      .9     1.0
    8                *     0   INFLOW                                          1
    9                *1                       RUNOFF TO HOYERTOWN RESERVOIR
   10                *     1        1     0.5                                                1
   11                P     0       23     113     123     132     142
   12                *                                                 1.0    0.05
   13                *   0.9     0.65
   14                *  -1.5     -.05       2
   15                *     1   OUTFLO                                          1
   16                *1                       ROUTING THROUGH HOYERTOWN RESERVOIR
   17                *                             1       1
   18                K1    1                                           -.625
   19                K4   0.2       9      22
   20                K    595     625     640
   21                K4   625       20     3.1     1.5
   22                K0  629.7      3.1    1.5     600
   23                *    99
```

Sh 2

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION  25 SEP 78
**********

RUN  DATE= 05/17/79.
     TIME= 13.49.00.
```

NATIONAL DAM INSPECTION PROGRAM
ROYERTOWN DAM
PMF HYDROGRAPH

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
150	0	30	0	0	0	0	0	4	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 9 LRTIO= 1

RTIOS= .20 .30 .40 .50 .60 .70 .80 .90 1.00

SUB-AREA RUNOFF COMPUTATION

RUNOFF TO ROYERTOWN RESERVOIR

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
INFLOW=	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	.50	0.00	.50	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.00	113.00	123.00	132.00	142.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .900

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOW	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA
TP= .90 CP= .55 NTA= 0

RECESSION DATA
STRTQ= -1.59 QRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 8 END-OF-PERIOD ORDINATES, LAG= .89 HOURS, CP= .64 VOL= 1.00

79. 213. 208. 92. 37. 15. 6. 2.

Sh 3

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q

SUM 28.13 23.73 2.40 16278.
(664.)(603.)(61.)(460.96)

HYDROGRAPH ROUTING

ROUTING THROUGH ROYERTOWN RESERVOIR

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
OUTFLO	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.001	0.000	0.000	-625.	0

SURFACE AREA=	0.	9.	22.
CAPACITY=	0.	105.	331.
ELEVATION=	595.	625.	640.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
625.0	20.0	3.1	1.5	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
629.7	3.1	1.5	600.

PEAK OUTFLOW IS 315. AT TIME 41.50 HOURS

PEAK OUTFLOW IS 490. AT TIME 41.50 HOURS

PEAK OUTFLOW IS 662. AT TIME 41.00 HOURS

PEAK OUTFLOW IS 1076. AT TIME 41.00 HOURS

PEAK OUTFLOW IS 1295. AT TIME 41.00 HOURS

PEAK OUTFLOW IS 1383. AT TIME 40.50 HOURS

PEAK OUTFLOW IS 1561. AT TIME 41.00 HOURS

PEAK OUTFLOW IS 1746. AT TIME 41.00 HOURS

PEAK OUTFLOW IS 1936. AT TIME 41.00 HOURS

Sh 4

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS								
				RATIO 1 .20	RATIO 2 .30	RATIO 3 .40	RATIO 4 .50	RATIO 5 .60	RATIO 6 .70	RATIO 7 .80	RATIO 8 .90	RATIO 9 1.00
HYDROGRAPH AT	INFLOW	.50	1	397.	596.	794.	993.	1191.	1390.	1588.	1787.	1985.
		(1.29)		(11.24)(	16.87)(	22.49)(	28.11)(	33.73)(	39.35)(	44.97)(	50.60)(	56.22)
ROUTED TO	OUTFLO	.50	1	315.	485.	662.	1076.	1195.	1383.	1561.	1746.	1936.
		(1.29)		(8.92)(	13.58)(	18.75)(	30.47)(	33.83)(	39.16)(	44.20)(	49.44)(	54.76)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	625.00	625.00	629.70
STORAGE	105.	105.	156.
OUTFLOW	0.	0.	632.

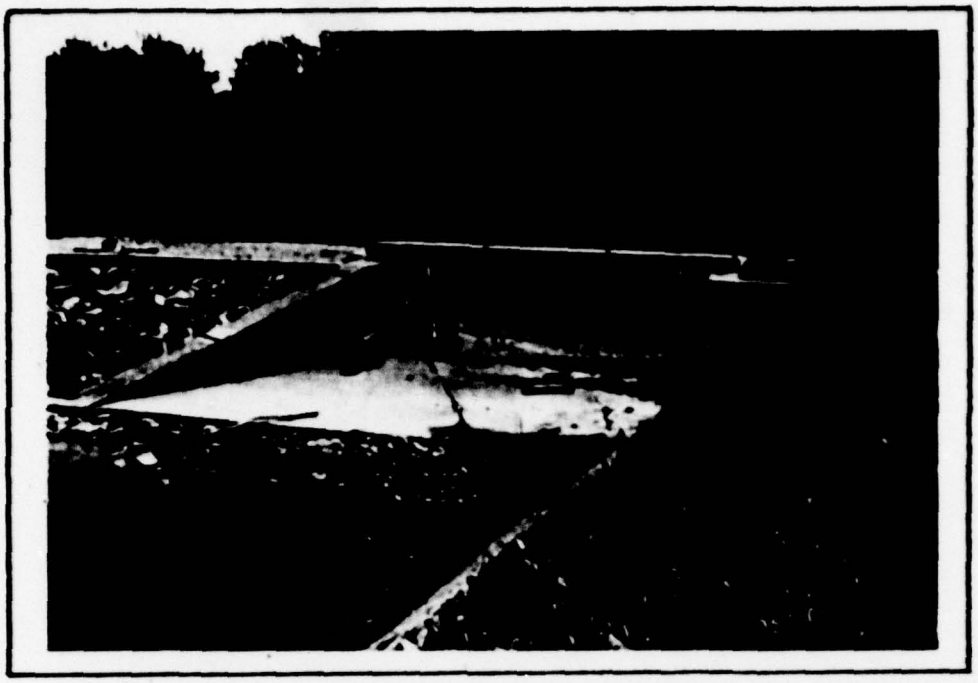
RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	627.96	0.00	135.	315.	0.00	41.50	0.00
.30	628.91	0.00	146.	488.	0.00	41.50	0.00
.40	629.75	.05	156.	662.	1.00	41.00	0.00
.50	630.04	.34	160.	1076.	1.50	41.00	0.00
.60	630.11	.41	161.	1195.	2.00	41.00	0.00
.70	630.20	.50	162.	1383.	2.50	40.50	0.00
.80	630.27	.57	163.	1561.	3.50	41.00	0.00
.90	630.35	.65	164.	1746.	3.50	41.00	0.00
1.00	630.43	.73	165.	1934.	4.00	41.00	0.00

Sht 6

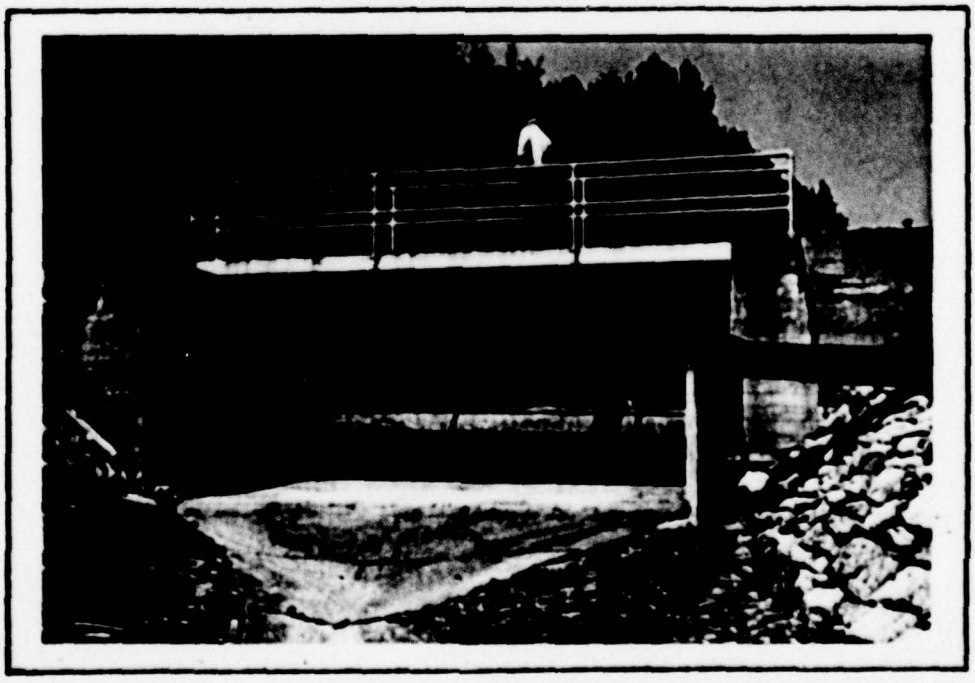
APPENDIX

D

Photographs

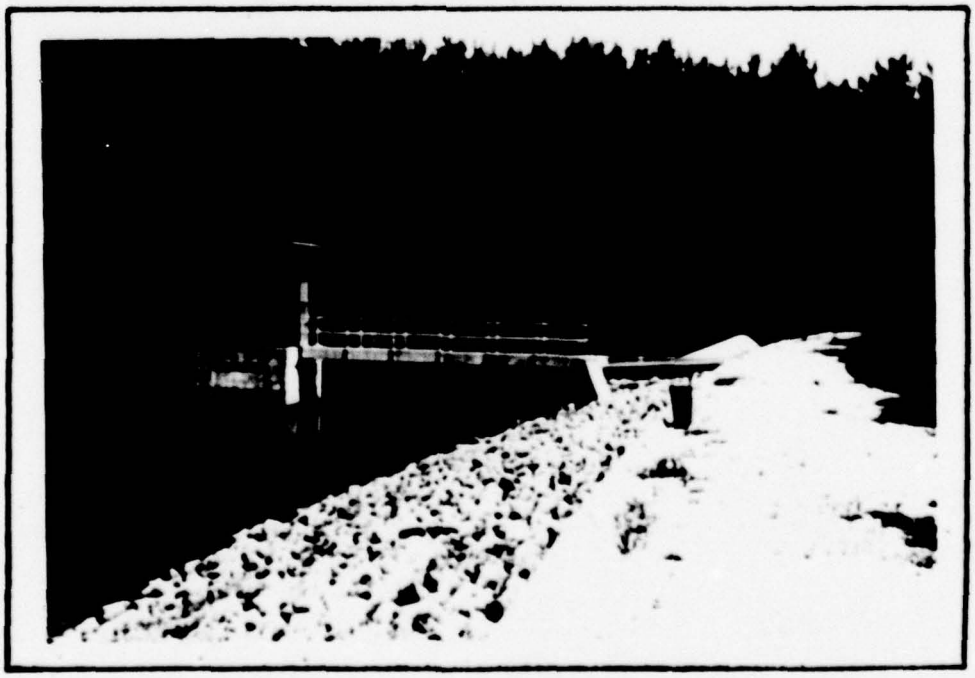


UPSTREAM VIEW OF THE SPILLWAY
NEAR THE RIGHT ABUTMENT

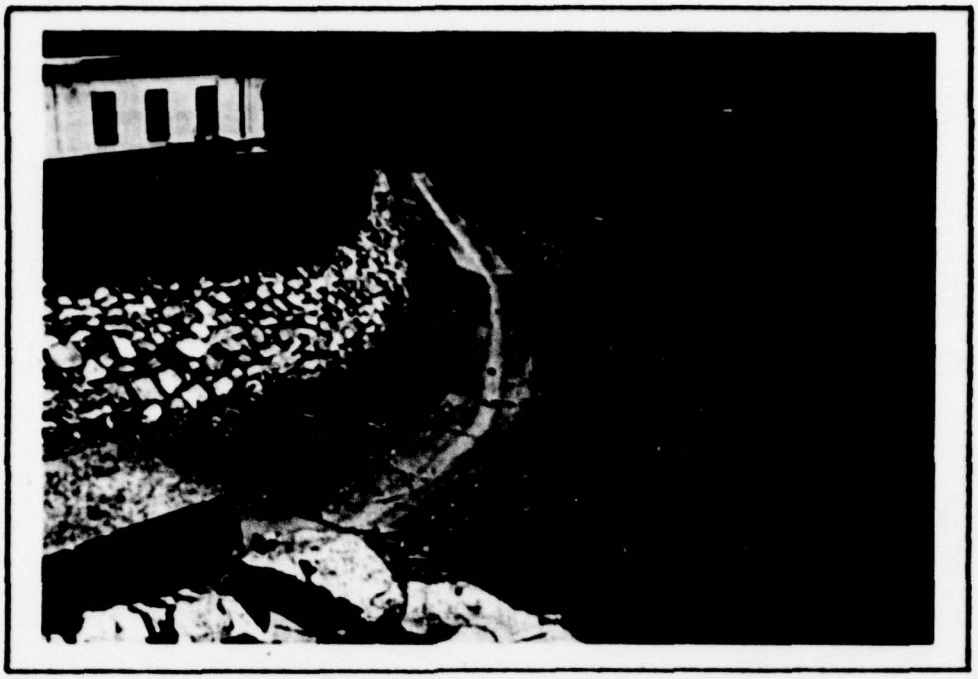


DOWNSTREAM VIEW OF THE SPILLWAY

VIEW OF THE OUTLET END OF 12 INCH DIAMETER PIPE WHICH CARRIES WATER FROM TROUT RUN RESERVOIR 2 MILES TO THE WEST

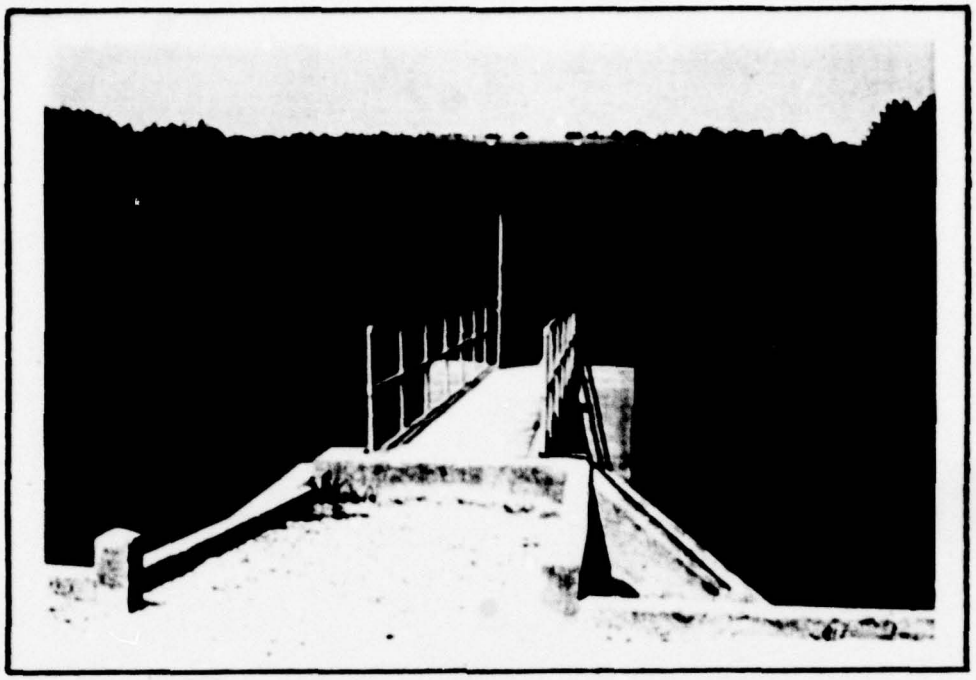


UPSTREAM FACE AND CREST OF THE DAM SHOWING THE GATEHOUSE, CATWALK AND CURBING ALONG THE TOP OF THE DAM



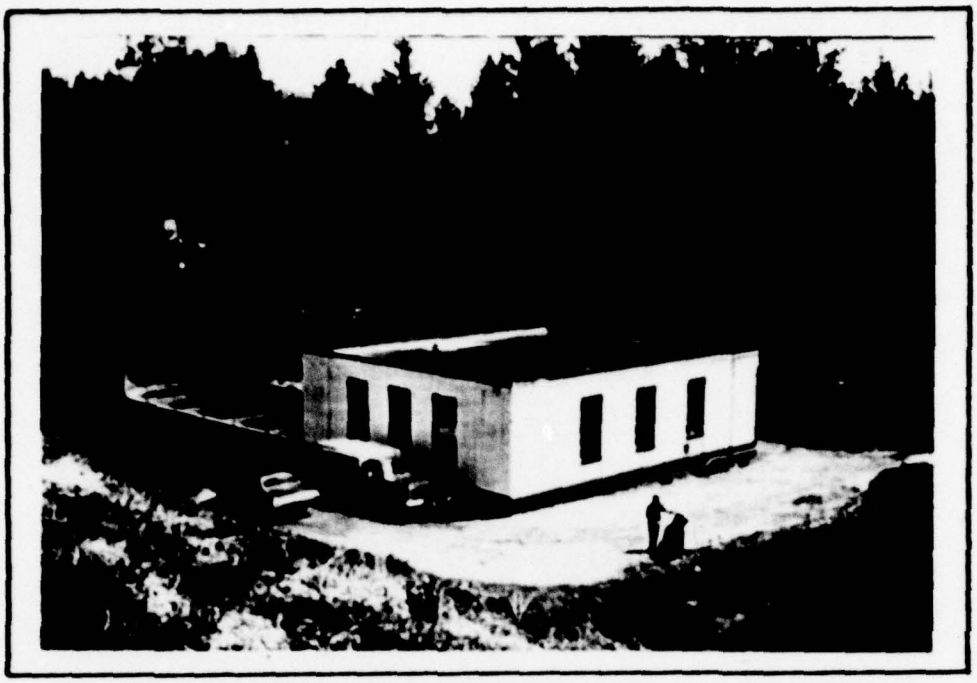
THE SPILLWAY DISCHARGE CHANNEL AS VIEWED FROM THE CREST OF THE DAM

THE SPILLWAY DISCHARGE CHANNEL CULVERTS BENEATH THE ACCESS ROAD

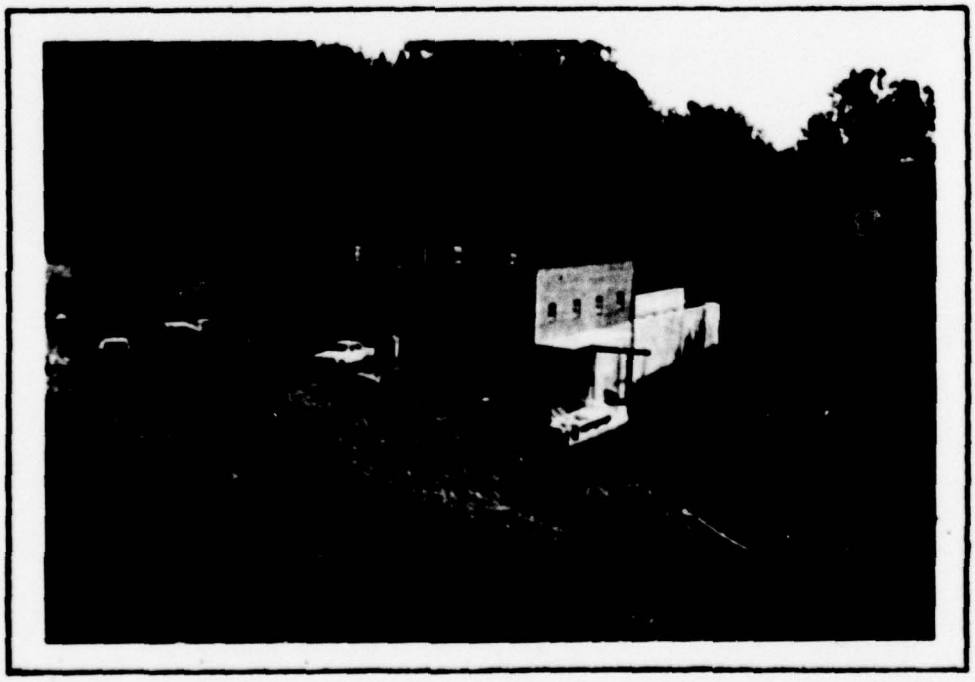


VIEW OF THE GATEHOUSE LOOKING
TOWARDS THE RESERVOIR

INTERIOR VIEW OF THE GATEHOUSE
SHOWING THE GATE HOISTS



THE TREATMENT PLANT BUILT IN 1926 LOCATED AT THE DOWNSTREAM TOE OF THE DAM



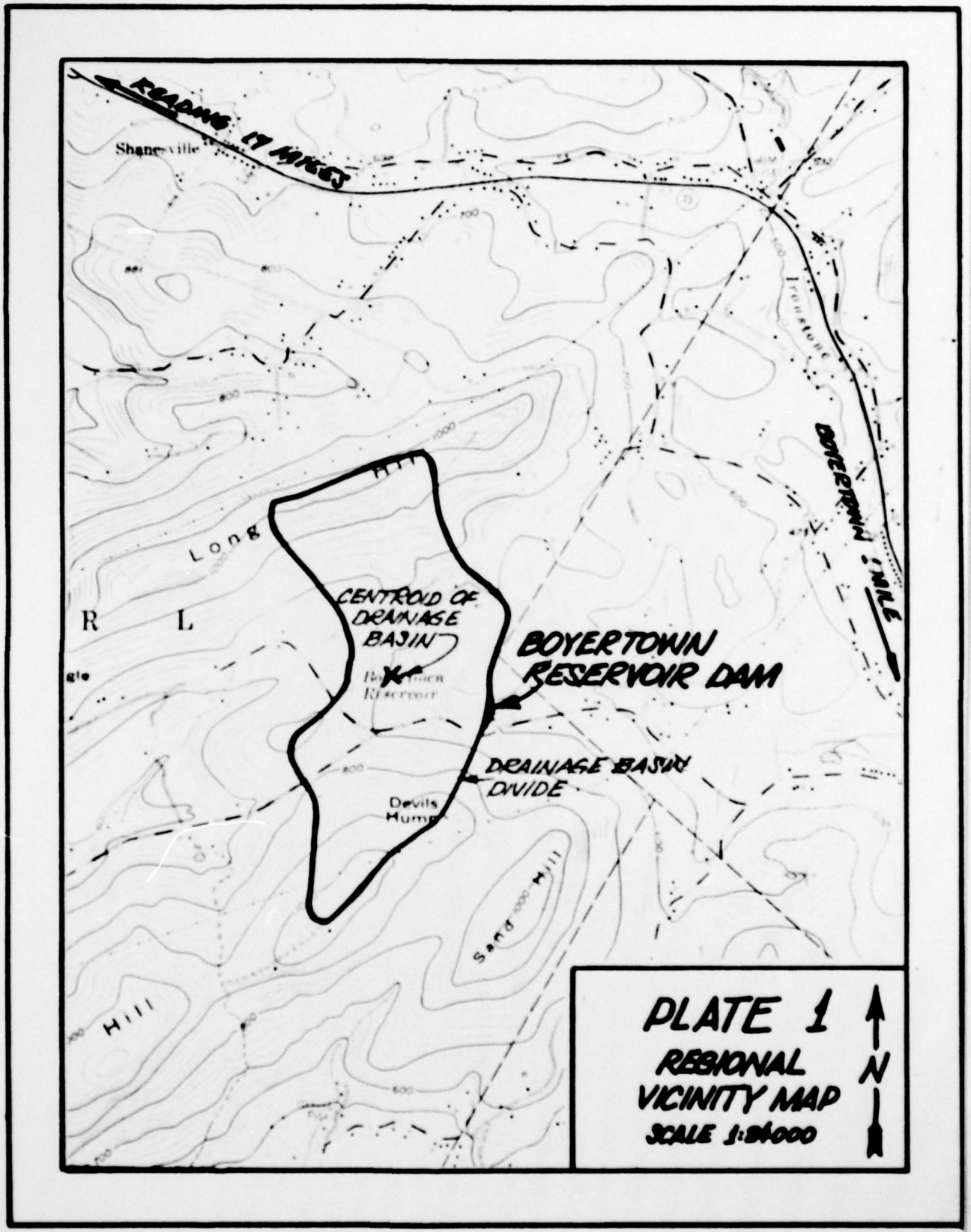
THE NEW TREATMENT PLANT LOCATED DOWNSTREAM OF THE LEFT ABUTMENT OF THE DAM

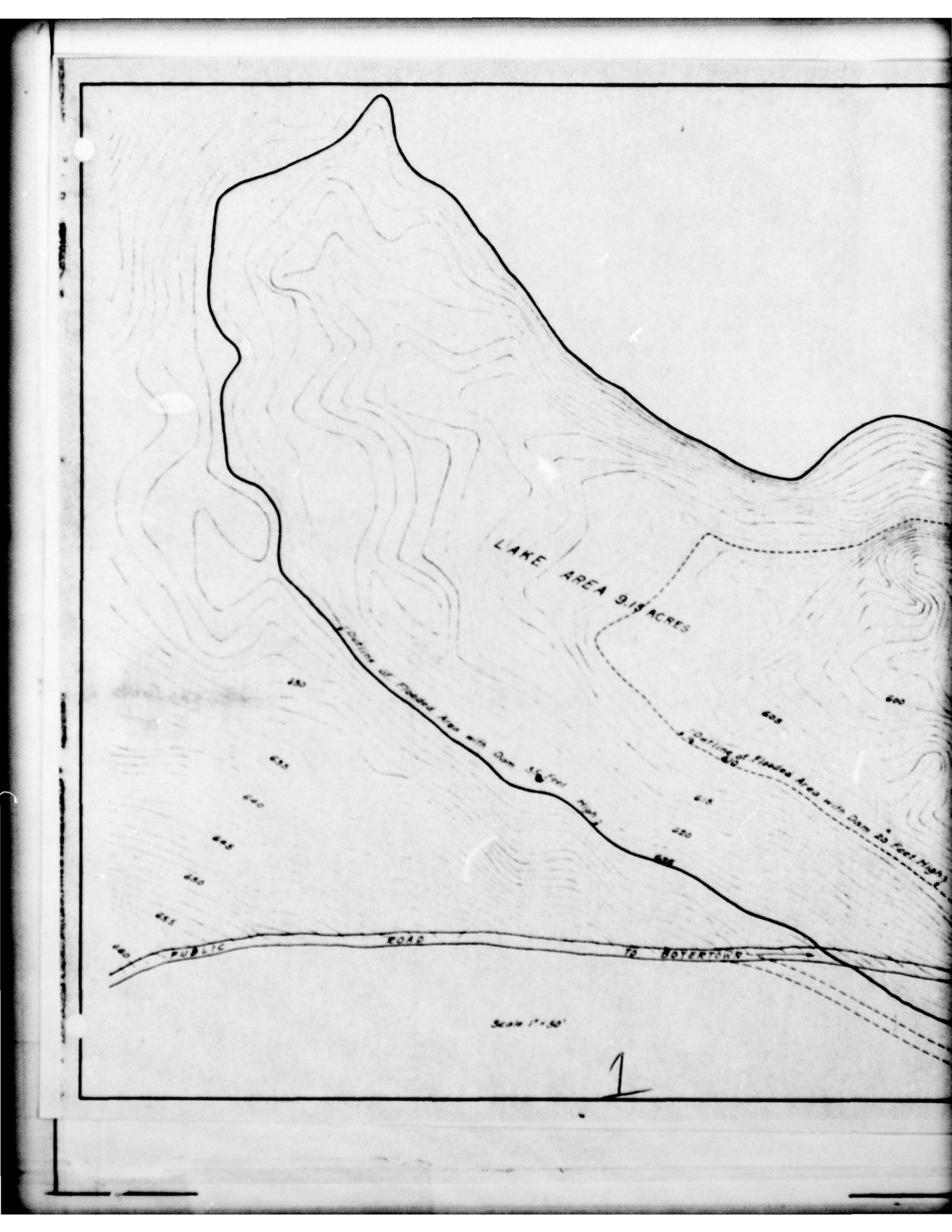
APPENDIX

E

Drawings

TABLE OF CONTENTS - APPENDIX E


ROADWAY TO MYERS
Shanesville
BOYERTOWN - MILL
Long
Hill
CENTROID OF DRAINAGE BASIN
BOYERTOWN RESERVOIR DAM
DRAINAGE BASIN DIVIDE
Devils Hump
Sand Hill
Hill
PLATE 1
REGIONAL VICINITY MAP
SCALE 1:24000
N


LAKE AREA 9.19 ACRES
Outline of Flooded Area with Dam 35 Feet High
Outline of Flooded Area with Dam 20 Feet High
PUBLIC ROAD TO BOYERTOWN
Scale 1"=50'
1

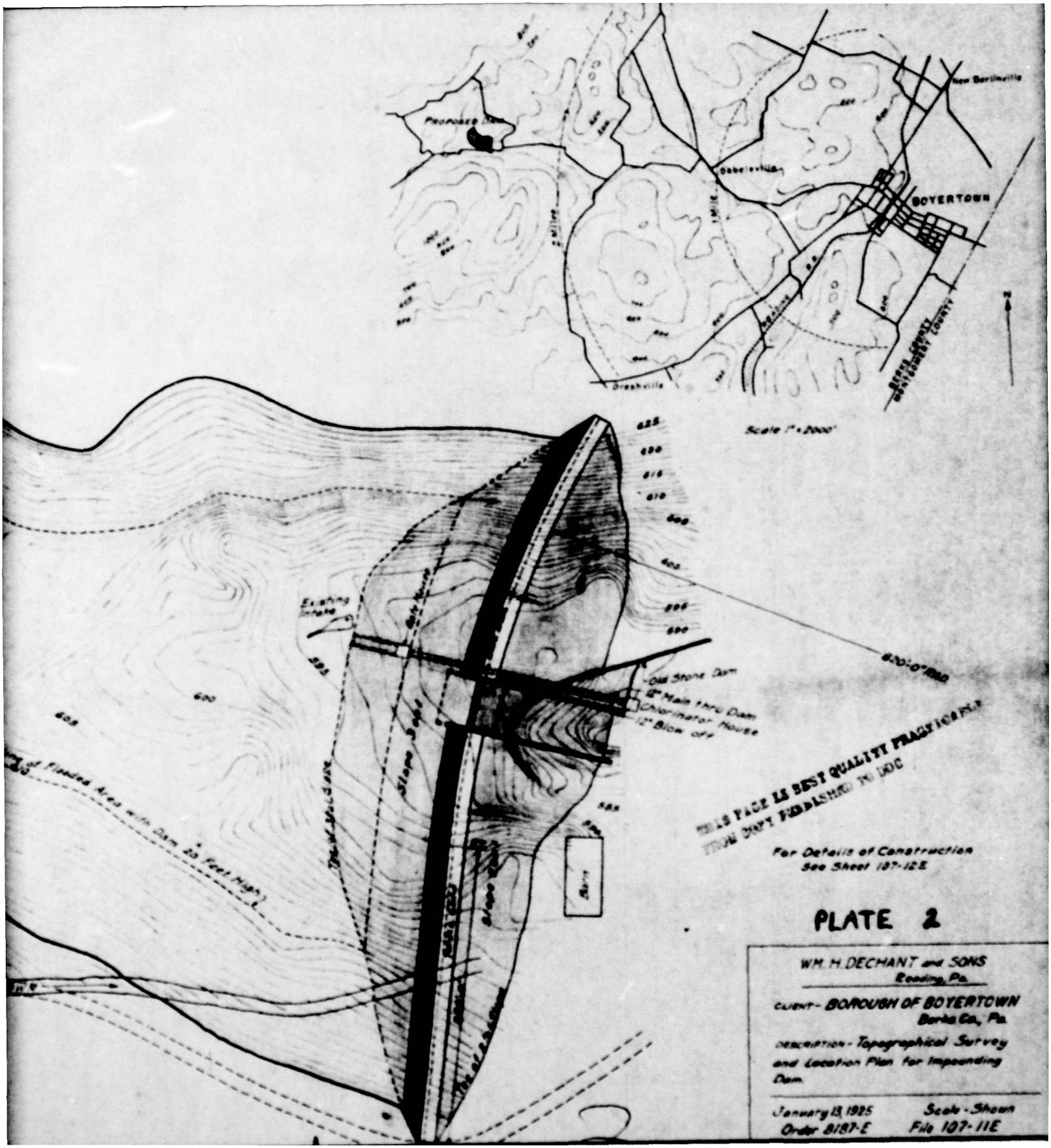


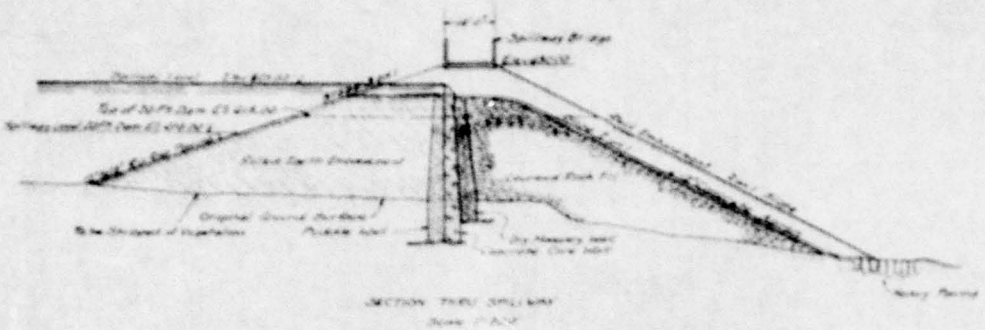
PLATE 2

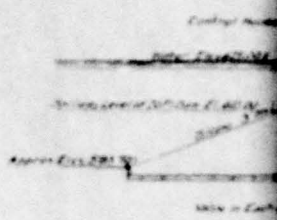
WM. H. DECHANT and SONS
Reading, Pa.

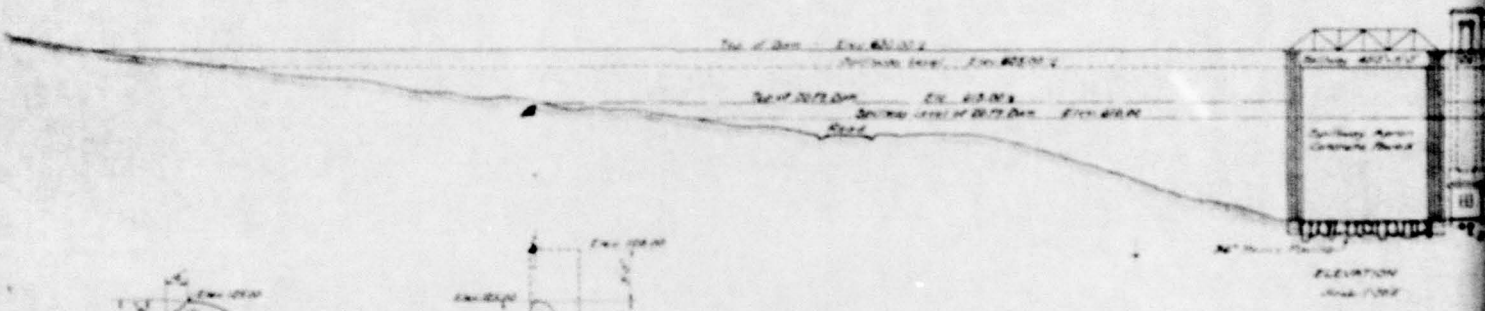
CLIENT - BOROUGH OF BOYERTOWN
Berks Co., Pa.

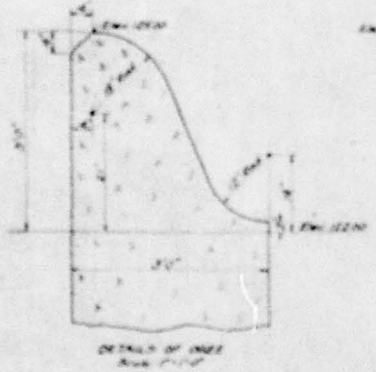
DESCRIPTION - Topographical Survey and Location Plan for Impounding Dam.

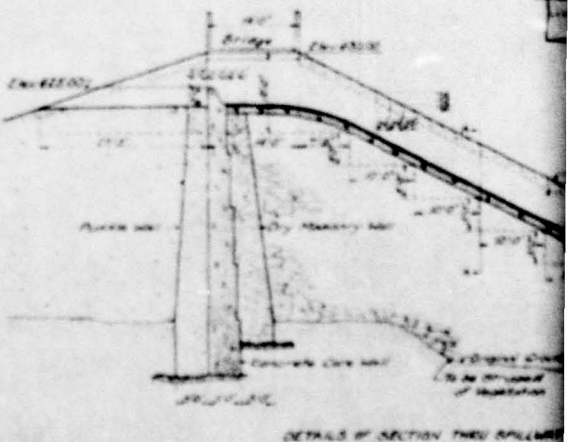
January 13, 1925 — Scale - Shown
Order 8187-E — File 107-11E











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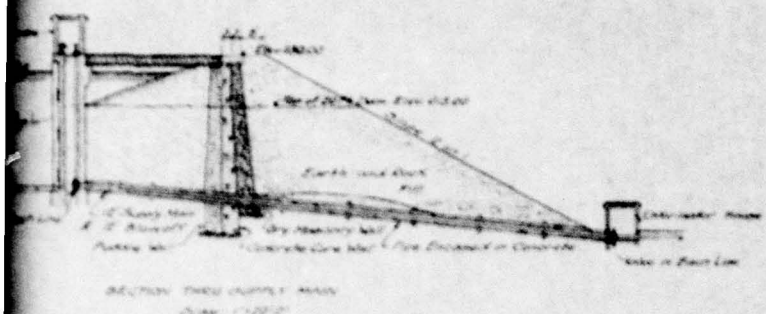
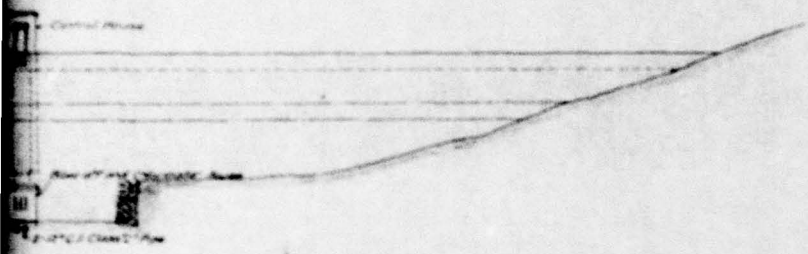
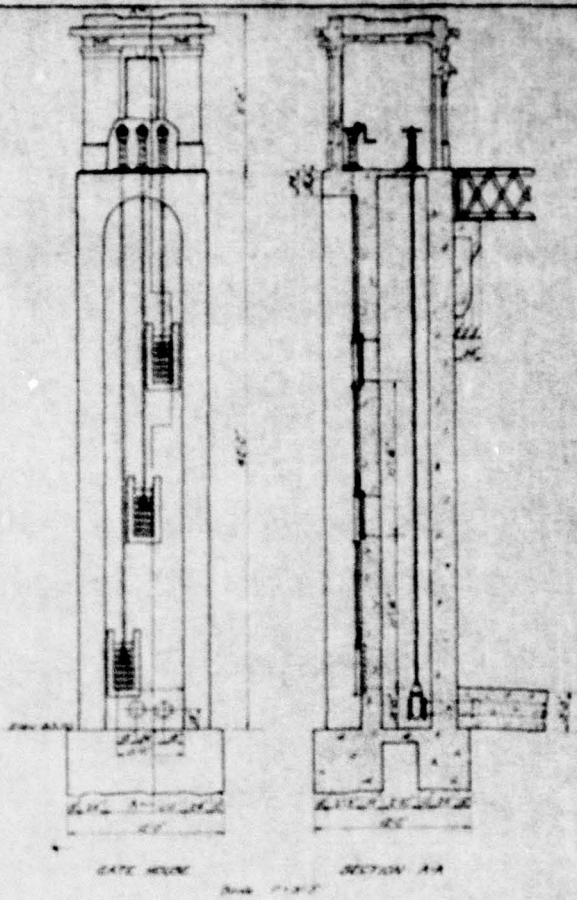
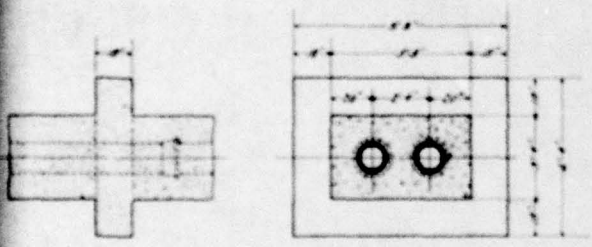
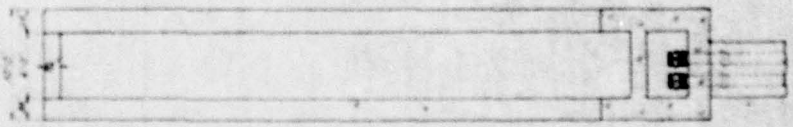
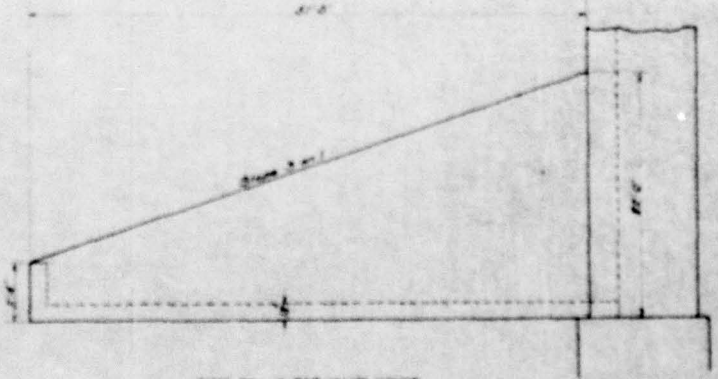












PLATE

WM H DECHANT and SONS

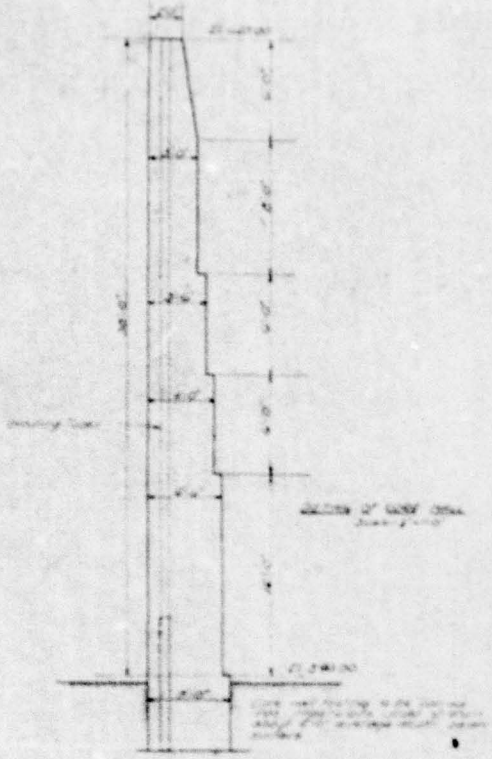
BOARD OF SUPERVISORS

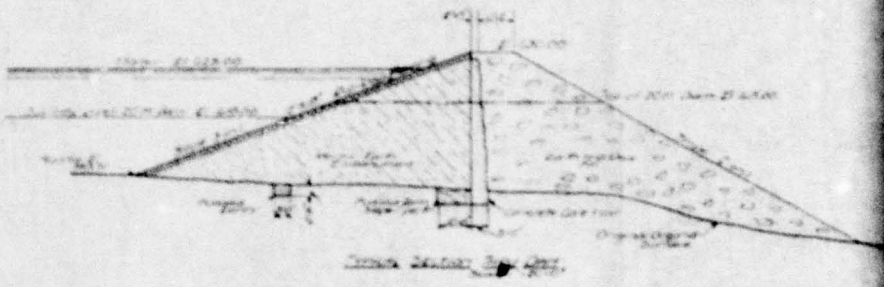
Sections and Details for Impounding Dam

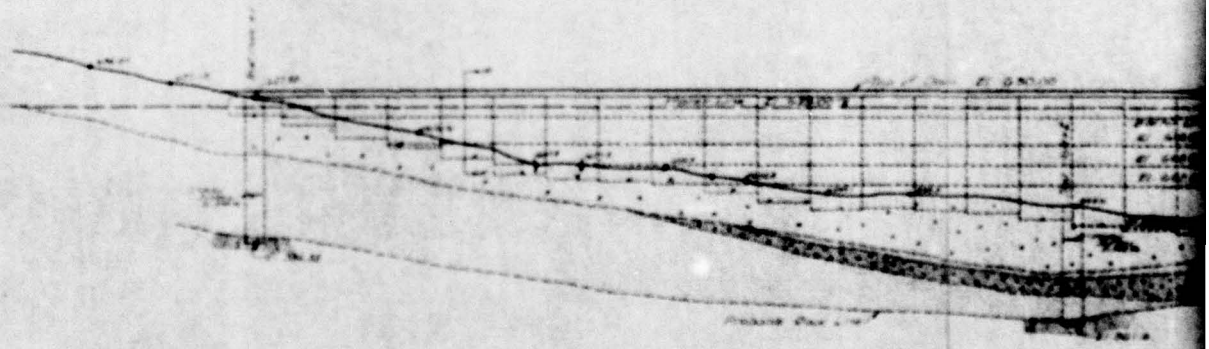
Dec 27 1924

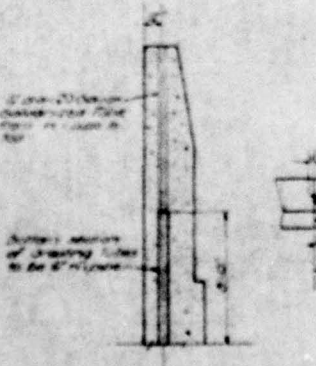
Order 8372

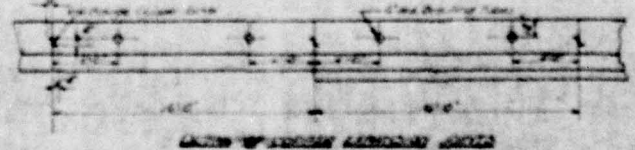
2

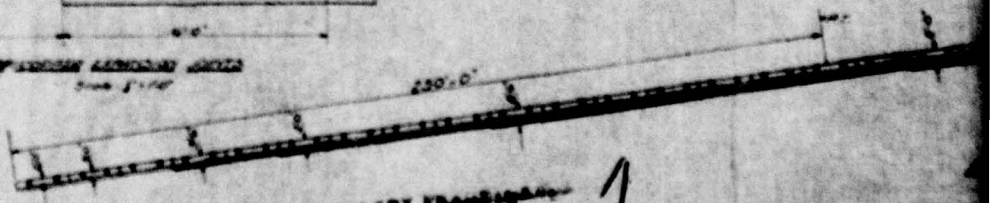


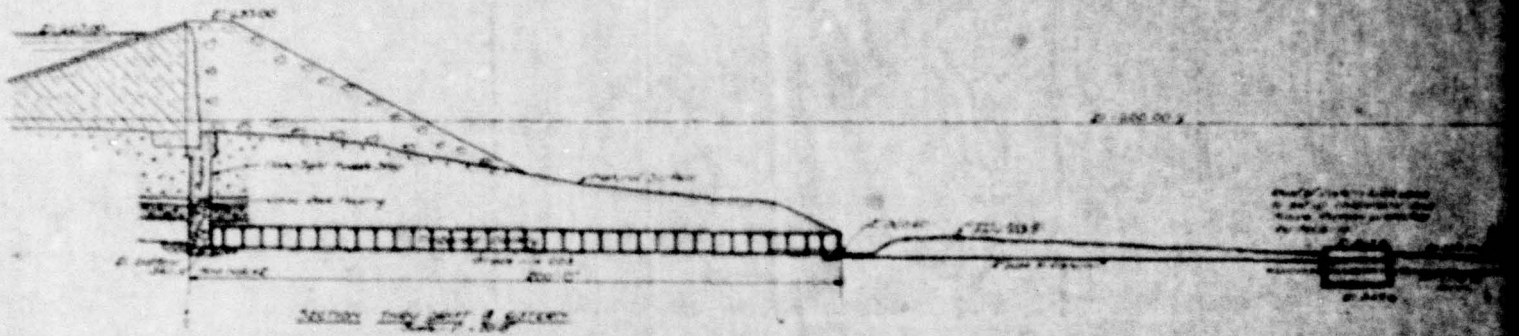


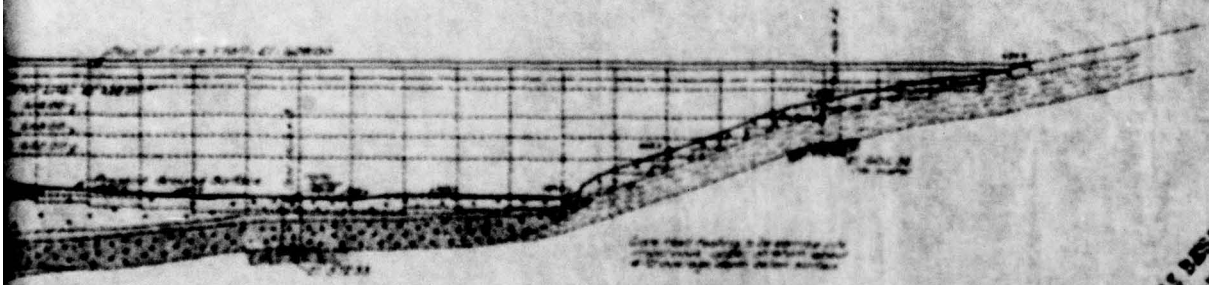


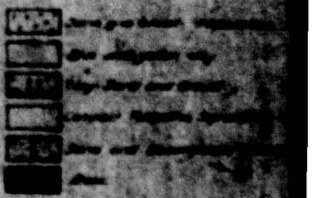


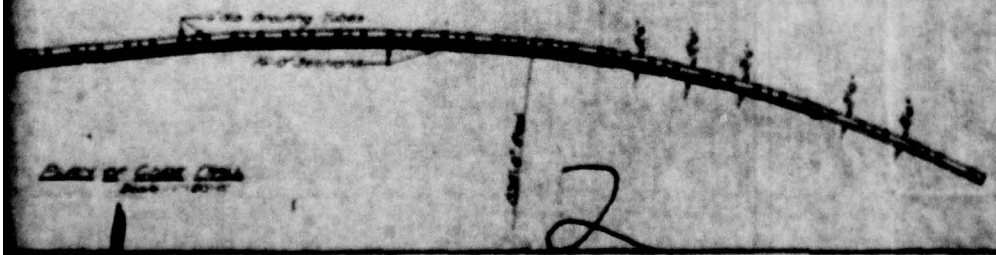






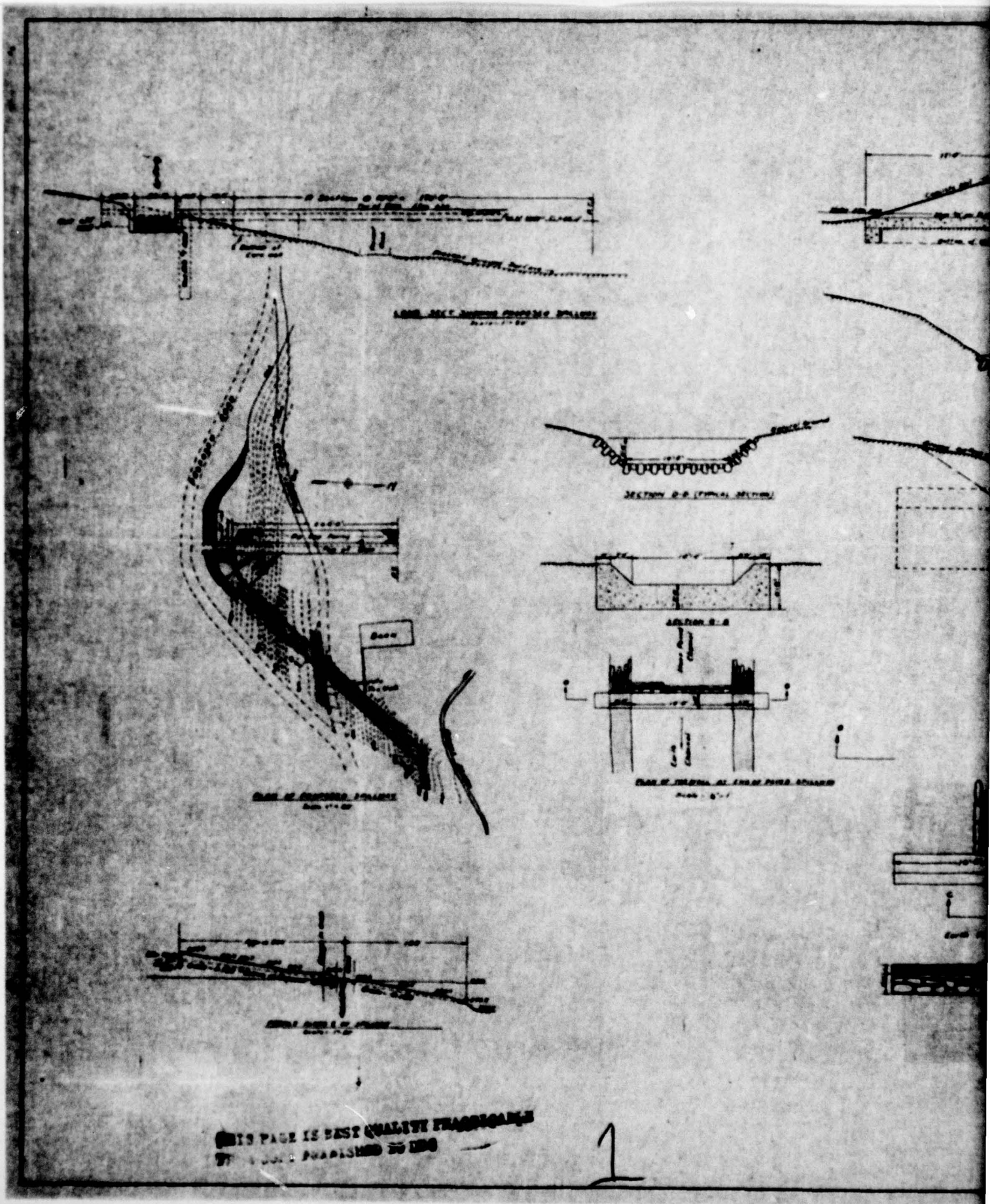






PLATE

2



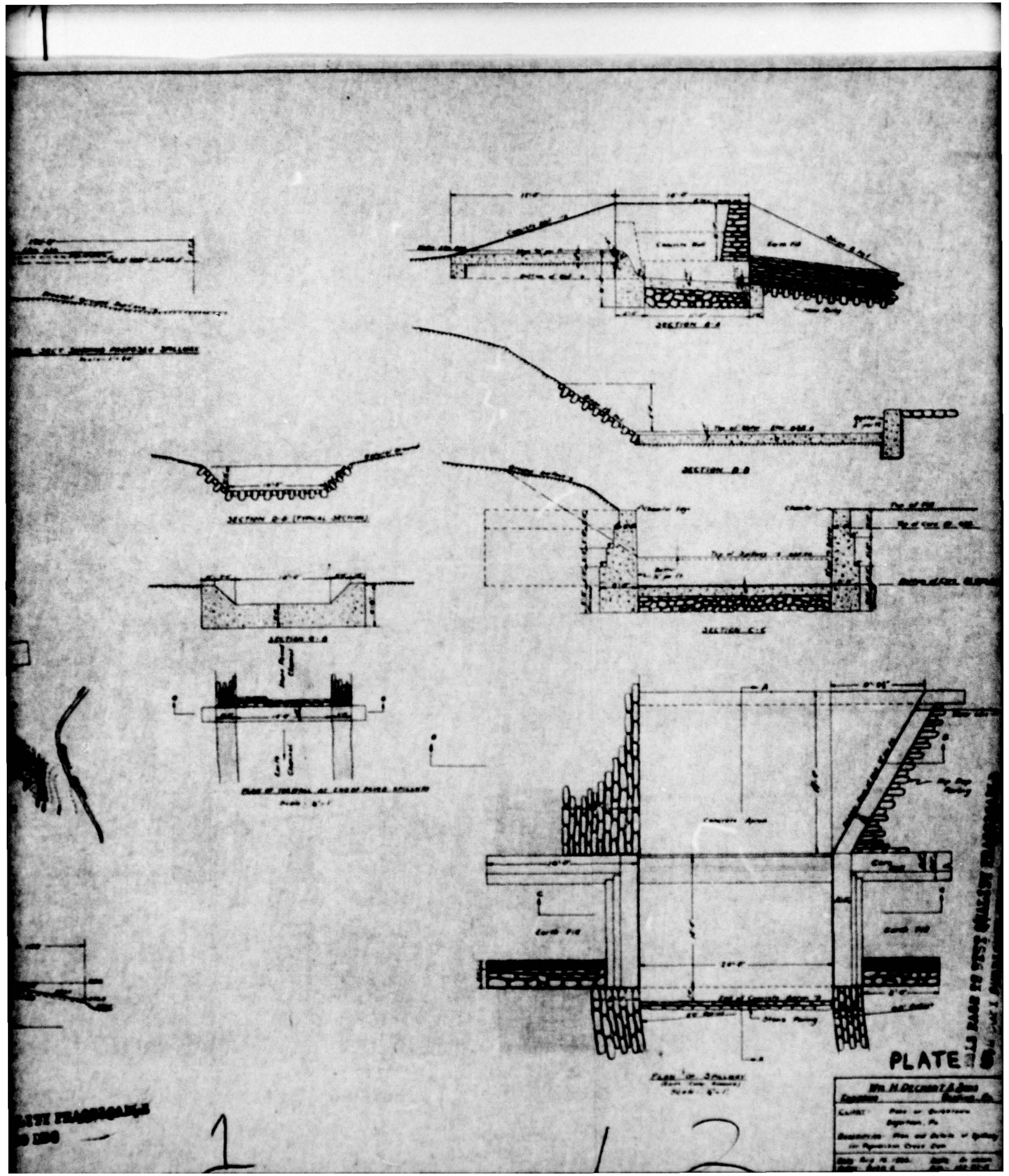


PLATE 6

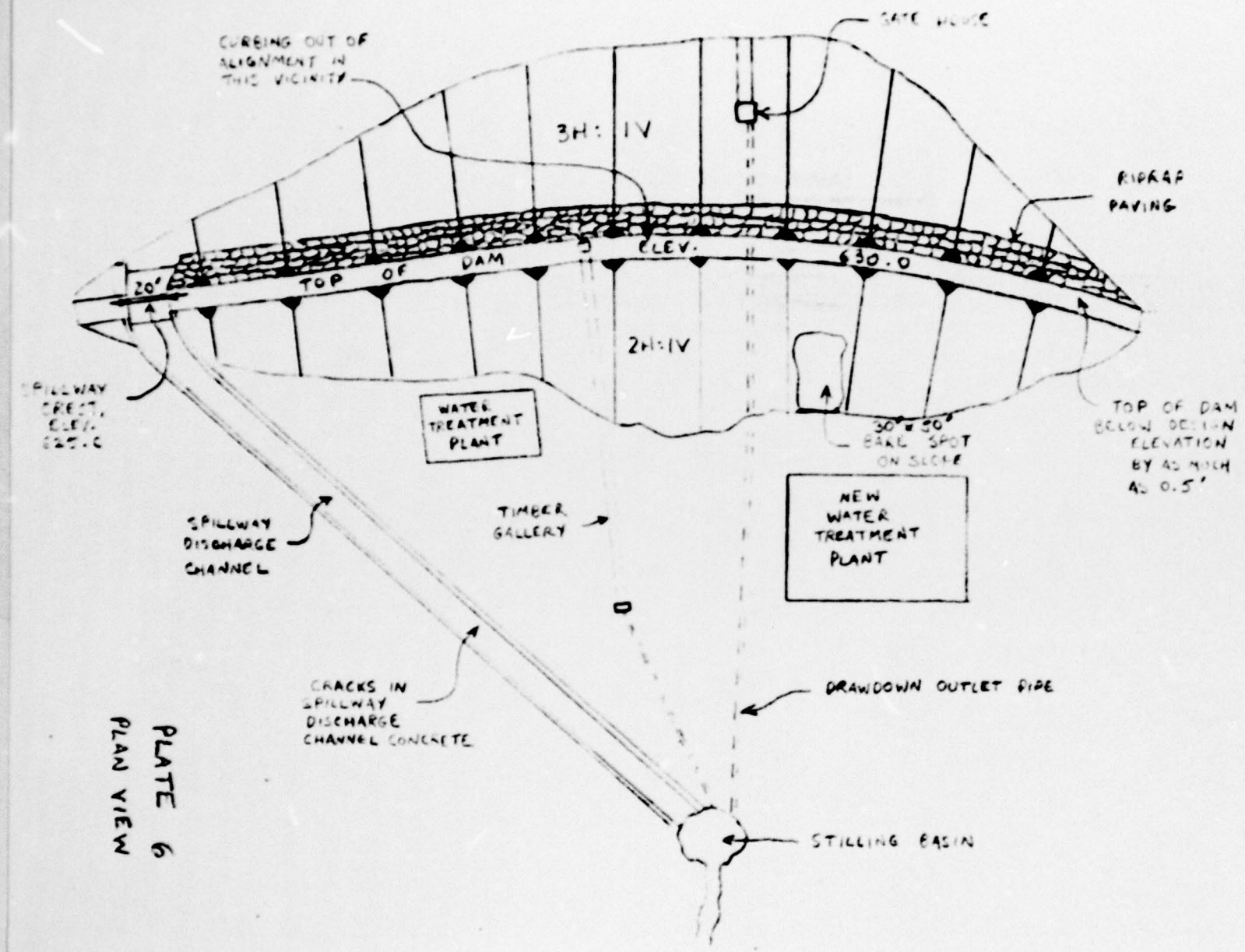


PLATE 6
PLAN VIEW

O'BRIEN & GERE ENGINEERS INC.

SUBJECT: BOYERTOWN DAM

SHEET | BY | DATE | JOB NO

O'BRIEN & GERE ENGINEERS, INC.

SUBJECT	SHEET	BY	DATE	JOB NO
BOYERTOWN DAM				

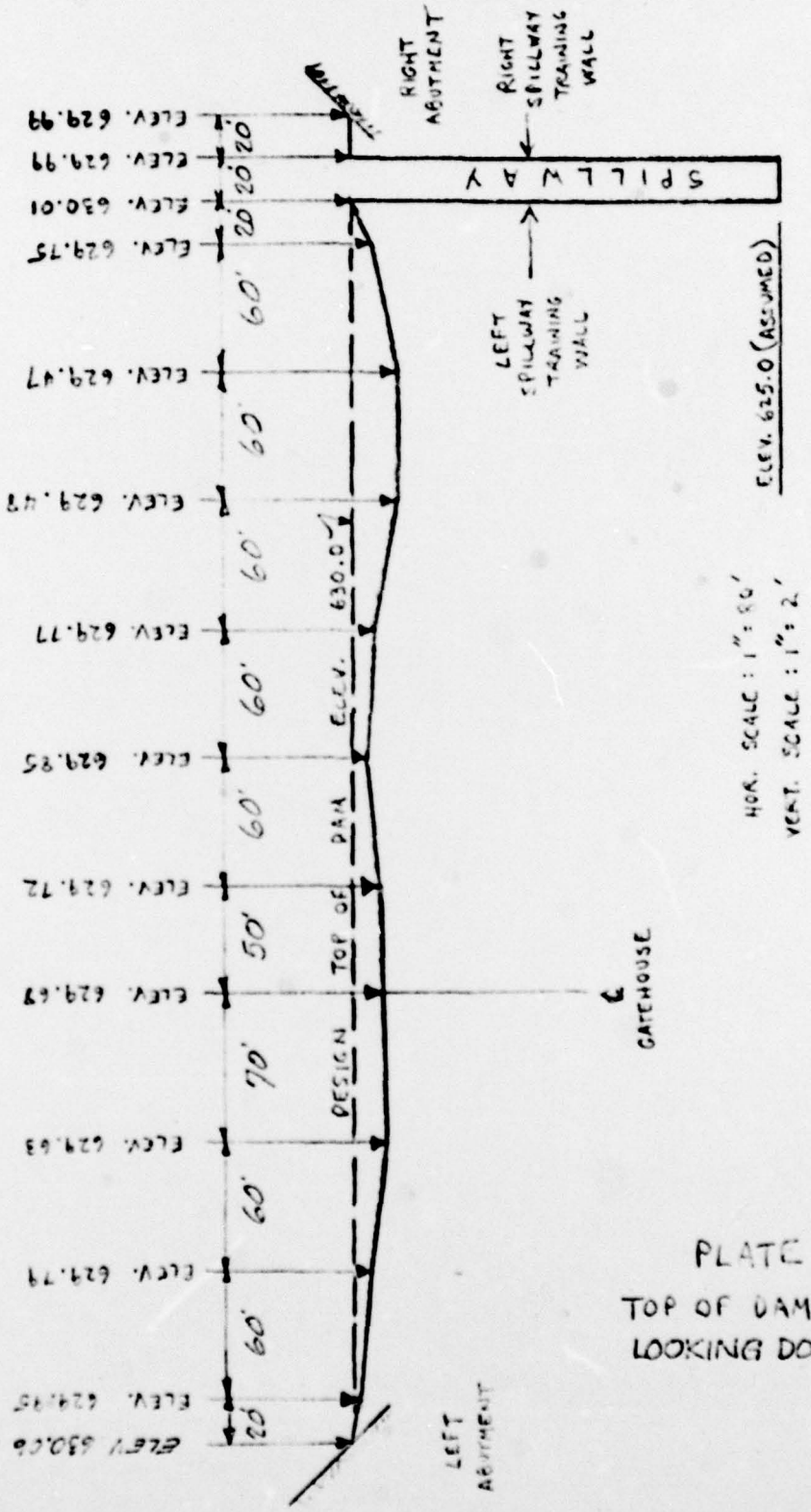


PLATE 7

TOP OF DAM PROFILE
LOOKING DOWNSTREAM

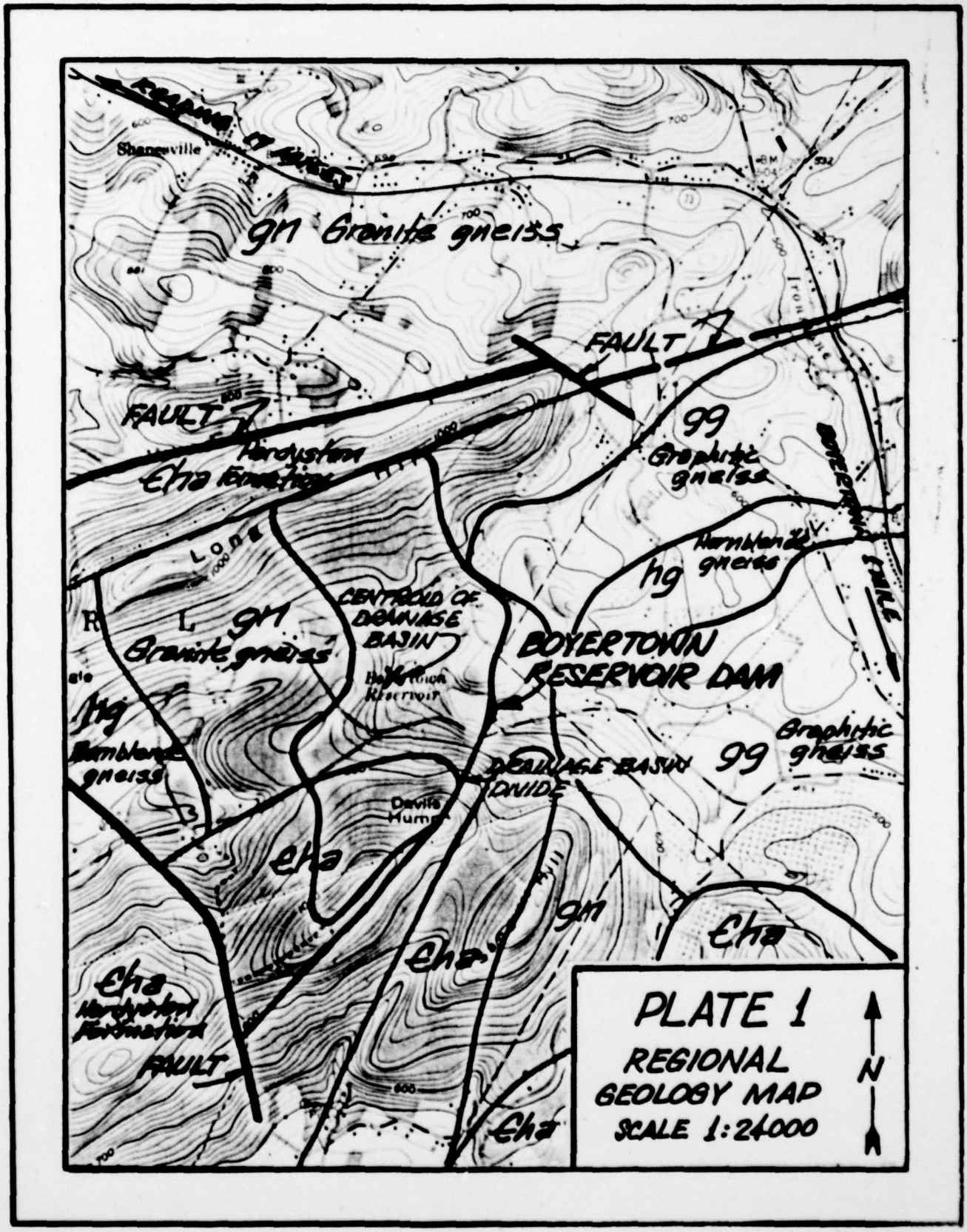
APPENDIX

F

Site Geology

SITE GEOLOGY

Boyertown Dam is located in the Reading Prong of the New England Uplands physiographic province. The crystalline rocks in this province are folded and highly faulted complex Precambrian metamorphics. Bedrock at the dam site is probably a granitic gneiss. However, inspection of the upper reaches of the reservoir indicated the presence of quartzite which comprises the Hardyston Formation.


Shanesville
gn Granite gneiss
FAULT
FAULT
Hornblende gneiss
Chs
99
Graphitic gneiss
hg
Hornblende gneiss
gn
Granite gneiss
CENTROID OF DRAINAGE BASIN
BOYERTOWN RESERVOIR DAM
DRAINAGE DIVIDE
Graphitic gneiss
99
Chs
Chs
Chs
Chs
Chs
FAULT
PLATE 1
REGIONAL GEOLOGY MAP
SCALE 1:24000
N